

Nonvolatile semiconductor memory: Trends and vision into nanoelectronics and tera-density era

C. Y. Lu and Simon M. Sze

Macronix International, Taiwan and National Chiao Tung University, Taiwan

The growth of nonvolatile semiconductor memory (NVSM) industry since the invention of floating-gate concept in 1967, has followed the Moore's law first, and later became the driver of Moore's law, as the fastest evolving electronic component in the recent 10 years. From 1985 to 2009, the penetration rate of NVSM, standalone and embedded, has already reached more than 90% in consumer and/or electronic equipment systems. Among these NVSMs, devices based on the floating-gate concept are the dominant winner.

In this review, we first briefly summarize the NVSM evolution and trends of the past and for the near future. The industrial efforts to drive the technology of Moore's law by NVSM down to the nanometer scale will be discussed in both economic and technical respects. The dramatic difficulties of scaling due to silicon technology limitations have engendered considerable economical turmoil and further consolidation in order to afford enormous research and development costs as well as mega-fab production facilities. Many innovations and efforts from academia and industry will enable this trend to continue; we will discuss some more or less mature new technologies that will sooner or later deliver lower-cost and higher performance NVSM to a storage class memory (SCM). In general, to move toward a multi-layer structure and multi-level cell developments shall be the direction. In addition, system level solutions and smart algorithms will be a must to make the existing technology to move toward its physical limitations.

These system solutions and smart algorithms will also enable the technological introduction of novel technologies. Many new but unproven innovations need to find a survival space to grow as a disruptive technology, eventually replacing the existing, mature NVSM technology. In the foreseeable future, the NVSM will continue meeting the demands of ever-lower cost, semiconductor device class of reliability (by the help from system solutions), and higher performance for many killer applications in newly created markets. This optimistic scenario, in turn, will significantly improve our quality of life and make it possible for people to live more freely and comfortably.